Evaluation of the Effectiveness of Project-Based Teaching Method in the Teaching and Learning of Geometrical Transformation at Ordinary Level. A Case Study of Marondera District of Mashonaland East Province, Zimbabwe.

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ABSTRACT

The major objective of this research project was to evaluate the effectiveness of the Project-Based Learning(PBL) method at Ordinary Level. Some progress record books, mark schedule at the particular school where the study was carried out were consulted and proved that most learners performed below average in the geometrical transformations. This research project used the quantitative research approach with experimental research design following an adoption of positivism philosophical paradigm. The population of the study were all form threes of the year 2023 and the sample selected was through cluster sampling procedure. Data were gathered from participants through questionnaires, observation and pre-test and post-test document. Analysis pointed out that basically PBL encourages independence, helps students gain and develop 21st century competencies such as critical thinking, creativity, collaboration and problem-solving skills. PBL activities were found to allow students develop deep content knowledge, assists learners to be directly involved in making decisions about the topic focus and the investigations involved. Profound information from a successful research done in South Africa by Nadia Rehman, Xiao Huang and Amir Mahmood on "Altering Students' Attitude Towards Learning Mathematics Through PBL" suggested that PBL increases motivation to learn, engagement and participation of learners in mathematics learning. Recommendations were made to parents, teachers and other stakeholders. It was suggested as a recommendation that parental involvement can also contribute to student success and motivation.

Keywords: Evaluation, Geometric Transformation, Performance, Project-Based Learning(PBL).

INTRODUCTION

Geometrical transformation is one of the most significant topics which prepares learners for further studies in Science and Mathematical related subjects, however, the way it is being taught does not guarantee a final product who has acquired, mastered and developed both conceptual and procedural mathematics as expected declares (Barbin, 2013). Arbarelo (2014) harmonise with this when he expressed that lack of reasoning skills on Geometrical transformation, Geometrical transformation language, comprehension, lack of visualising abilities are mostly blamed for the poor teaching methods and the instructional materials among other factors which contribute to the students perceived difficulty in the learning of Geometrical transformation. This concurs with (Barut, 2020) when he purports that the major contributors of challenges with teaching and learning of Geometrical transformation relate to the teaching pedagogy. This implies that the teaching methodology in the Geometrical transformations concepts should be improved, the traditional way of teaching Geometrical transformations is failing to significantly contribute to good results and hence the need for

mathematics teacher to explore on the newly proposed 21st century methodologies which incorporates, the use of hands-on learning methods. For instance, the Inquiry-Based teaching methods which includes: Project or Task-based, Ethno-mathematics, Realistic mathematics and Design-based teaching method. The use of these methods might positively change the current performance in the Geometrical transformations learning as learners might be motivated and enjoy doing fun Geometrical transformations activities. With the educational reform for problem solving and critical thinking skills in the 21st century era, a large number of scholars are exploring a range of dynamic 21st century teaching and learning methodologies and are recommending the classroom practitioners to try new inquiry-based teaching and learning methods for relational understanding. Educators and other education personnel, therefore, play a crucial role in promoting and protecting learners' mental health and psychosocial well-being. Positive relationships with educators can ensure adolescents feel safe, seen, supported and have a sense of belonging. Hence, this study intended to evaluate the effectiveness of the Project-Based Learning in the teaching and learning of the Geometrical transformations at Ordinary level at a particular school in Marondera District of Mashonaland East in Zimbabwe.

BACKGROUND

Worldwide educational history, mathematics education in Geometry and Geometrical transformations concepts have proved to be a mystery (Carl, 2016).A study by Dintari (2021) revealed that in the United States for grades pre-k through 12 the study of spatial objects, relationships and transformations is yielding low grades and the mathematical curriculum in the United States elementary and secondary school encounters a serious dilemma when it comes to Geometrical transformations and it is easy to find fault with the traditional course in Geometrical transformations, but sound advice on how to remedy these difficulties seems to be hard to come by. (Foster, 2019) reiterated that The Commission on Mathematics of the United States, the School Mathematics Study Group, the Illinois project and many other curriculum reform groups at home and abroad have tackled the problem but with singular lack of success or agreement while on the other hand arithmetic and algebra have made great strides. This implies that Geometrical transformations are being abandoned and more time is being given to the other branches of mathematics such as statistics, algebra and arithmetic. The chief reason for the abandonment is because of its complexity for both the teacher and the learners and hence need an excellent methodology to bring about meaningful results. There is a great need for Mathematics teachers to address this gap as soon as yesterday so that learners are motivated to learn Geometrical transformations and improve their performance in this concept.

In the United Kingdom (UK) a research by (Gerdes, 2016) which focused on learners between the age of 11-18, affirms that the issue of teaching for understanding Geometrical transformations concepts is a dispute and a puzzle which has remained unsolved and need immediate attention. A research by (Barbin, 2013) supplement that in UK, the conceptual understanding in Geometrical transformations optics, such as reflection, refraction, mirrors, and other geometric concepts remain an unsolved concern in the department of teaching and learning of mathematics at secondary school level. In support to this (Charlotte, 2021) in the UK exposed that the Programme for International Student Assessment (PISA) which compares the performance of ordinary level learners through Mathematics branches found out that Geometrical transformations was far more lagging behind in the learner performance. These researches reveal a gap in the teaching methods and styles in the learning of Geometrical transformations for relational understanding.

Moreover, France Mathematics Education Conference held in Paris, (2021) revealed that new strategies need to be put in place to enhance the conceptual or relational understanding of Geometrical transformations. A proposal was staged that the teachers should use activity-based teaching methods so that learners are involved in the construction of their knowledge. There is need to explore in the hands-on learning methods as well as incorporating visuals as suggested by the Van Hiele geometrical transformations theory. Van Hiele proposes that the visual aspect is very important in the teaching of Geometry at any stage of learning as it allows learners to connect what they see with real-life situations.

Sub-Saharan countries the prevailing topic in Mathematics remains dominant in the domain of Geometry

reiterated (Joel, 2015). Geometrical transformations concepts understanding within the context of Southern African countries such as South Africa, Botswana and Mozambique need an instantaneous intervention through different inquiry-based teaching methodologies as to try and assist learners to acquire Geometrical transformations skills for life (Martins, 2015). This indicates that teachers must explore the effective ways of teaching Geometrical transformations at all levels and improve teaching strategies, student engagement and learning.

A research by (Mashingaidze, 2015) asserts that in Zimbabwe, Geometrical transformations is one of the most difficult topics in secondary school mathematics. Many learners perform poorly in Geometrical transformations according to Examiner Report, Zimbabwe Schools Examination Council (ZIMSEC) 2016 - 2022. Currently, a study by (Matunga, 2024) at Bindura University of Science Education, showed that there is a need to test the other 21st inquiry –based teaching methodology in the teaching and learning process. Thus,a different methodologies need to be tested used in their research in exploring Zimbabwean Mathematics Teachers' Integration of Ethno mathematics approaches into the Teaching and Learning of Geometry at Ordinary Level. This implies that the poor performance of learners might be credited to the poor methodologies being applied by the teachers in the learning of Geometry. The traditional teaching methods being used are not sufficient enough to enable learners understand or acquire relational knowledge rather learners will be just memorising facts and procedures such that within a short space of time they tend to forget the whole process involved in coming up with sound solution. This also suggests that learners are not developing necessary skills needed in the society to solve the real-life problems.

At this particular school in Marondera, the manifestation of Geometrical transformation being one of the topics not understood by learners were through Mathematics departmental minutes, Mathematics teachers' progress records where geometrical transformation tests and exercise are being recorded. Therefore, it was essential for this study to look into possible solutions in the aspect of the Geometrical transformations teaching and learning so that learners improve in the Geometrical transformations achievement. As related literature from various researches and international practices suggested that much more can and should be done in all grades pertaining the learning of Geometrical transformations. This implies that the teaching method should be inspected whether they fit in this fourth industrial revolution era for the relevance and understanding of Geometrical transformations concepts. Thus, the teaching and learning methods as well as styles should be re-visited as to improve learner performance in Geometrical transformations.

LITERATURE REVIEW

World-wide, learners' lack of Geometrical transformation understanding has gained significant attention in the recent years. Secondary school learners face various challenges in trying to understand Geometrical transformations at Ordinary level. This section, therefore, reviews related literature on various studies involving teaching methodologies in the teaching and learning of Geometry and Geometrical transformations at different learning levels. By interrogating existing literature, this study aims to shed light on effective interventions that may result in positive and fruitful ways of teaching Geometrical transformation for relational understanding. (Arbarelo, 2014) suggests that learners are able to construct their own knowledge, reflect upon their learning projects results in increased motivation and self-efficient, enhancement of creative thinking skills, promotes and provide student-faculty interaction, increases student retention, self-esteem and responsibility and promotes Ethno mathematics. This means that given the opportunity to explore for themselves, learners understand well.

Literature reveals that PBL is a key strategy for creating independent and critical thinkers. (Barut, 2020) reiterates that PBL activities allows learners to explore and experiment with the materials in the learning environment developing their reasoning skills to think logically, systematically, critically and thoroughly. In support to this, (Charlotte, Skipp , Dommett, Eleanor , 2021) argued that Problem-based teaching method enable students to think creatively and critically by using progressive and challenging thought processes; creative and critical thinking will help develop a nation and address its needs. Thus, PBL enable learners to adopt an objective and open attitude when dealing with problems.

Studies have indicated that PBL method avail a lot of teaching materials in an effort to make learners comprehend the concerned content. According to (Battista, 2017) strengthened that by using the project-based teaching method, a diversity of the teaching materials can ultimately lead to a greater appreciation for the beauty and complexity of Geometrical transformations, as well as the development of significant skills for academic and professional success. (Asterhan & Schwarz, 2017) highlighted that teachers and learners are encouraged to use descriptions, demonstrations and justifications in order to develop reasoning skills and the confidence required to underpin the development of an ability to follow and construct Geometrical transformations proofs. The related literature coins with the van Hiele theory which proposes the use of a variety of materials and representations such as diagrams, models, and computer simulations will help learners to help visualise and understand the abstract Geometrical transformations concepts. The literature also indicates that there is need to allow a good understanding of the basic geometrical transformations concepts and language of Geometry in order to provide foundations for future work and to enable learners to consider Geometrical transformations problems and communicate ideas.

Various scholars have made noteworthy efforts to bring to light that students exposed to a PBL curriculum had better performance on energy-related knowledge, attitudes, behaviours, and beliefs. Rendering to (Arbarelo, 2014) who highlighted that quantitative results of different studies showed that students exposed to the PBL curriculum outperformed students taught using the traditional curriculum. According to (Carl, 2016) the results of Zhang Ying's intrinsic motivation scale, which was administered to 21 private university students before and after they received project-based learning, showed that there were significant differences in students' interest, autonomy, and competence before and after, which positively influenced students' intrinsic motivation to learn.The literature suggests that students exposed to the PBL course outperformed students taught with traditional courses in terms of energy-related knowledge, attitudes, behaviours, and beliefs.

The related literature suggested that, in the project-based teaching and learning method, skills which enables collaboration and team work among students is encouraged and provides an opportunity for students to work together, share their ideas and learn from one another. Students can also learn to work with people from different backgrounds with different perspectives on different aspects of life. (Juran, 2020)posits that the project-based teaching promotes and provide student-faculty interaction, thereby increasing student retention, self-esteem and responsibility. The assertion agrees with (Charlotte, Skipp , Dommett, Eleanor , 2021) when he reiterates that through project-based teaching method learners there is development of oral communication, self-management, leadership skills and an increase in understanding of diverse perspective. Thus, students collaboratively realise the notion of the place of the axioms, appreciate the significance of the proofs, understanding these proofs and the of constructing simple proofs.

With regards to reviewed literature, it is evident that educators need to explore the Project-based teaching method in the teaching and learning of Geometric transformations at Ordinary level. For this reason, this study sought to gain an in-depth understanding on how effective the Project-based teaching and learning method in the teaching of Geometrical transformation at a selected school in Marondera District is. The following research questions guided the study:

I. How does the PBL effect students' motivation and engagement in the learning of geometrical transformations?
II. What are the differences in learning outcomes between learners taught using PBL method and those taught using traditional teaching methods?
III. What are the challenges faced by the teachers in implementing the PBL method?

METHODS

The underlying philosophical paradigm which was employed in the evaluation of the effectiveness of the PBL was the positivism paradigm. The positivism paradigm covers a wide range of situations in a short space of time (Suyutino, Eka, & Budhiati, 2019). Quantitative research approach was employed because of its objectivity since it relies on concrete numbers and few variables. Thus, it allowed the researcher to generate a

testable and realistic hypothesis. The experimental research design method was adopted by providing treatment through the implementation of PBL, the goal was to compare the situation before and after the experiment.

In this study, ninety-two form three learners and ten Science Technology Engineering and Mathematics (STEM) teachers accumulated to a total population of one hundred and two possible respondents. The researcher employed the cluster probability sampling techniques. Cross-tabulation for analysing data was employed in this study as it is one of the most suitable analysis method for quantitative data. Statistical t-test for independent means was utilised in testing the hypothesis. The current study was subject to certain ethical issues. Questionnaires, observation and document analysis for pre-test and post-test were used in addressing aspects of the evaluation of the effectiveness of the project-based teaching method in the teaching and learning of geometrical transformations at ordinary level to overcome the deficiencies of a single method (Sarantakos, 2013), as well as to gain richer data and contextualize the findings (Curtis & Curtis, 2011). Two sample t-test or t-test for independence means was used to determine whether there is a significant difference between the means of two samples.

During the research conduct some potential biases and constraints might have affected the results. The sample might not have been a true representative of the larger population leading to biased results. In addition to, the researcher during observations might unintentionally influence the results by expecting a specific outcome or having preconceived notions about the PBL. The researcher expertise and training in PBL, research methods and statistics might have affected the quality and validity of the research. On the other hand, students may respond to questionnaires in a way they think is socially acceptable rather than honestly. The limited time might have resulted in rushed data collection, presentation and analysis, hence affect the final results. Using the two-sample t-test, the data might have not met the assumption of normality, potentially leading to inaccurate results. The school policies, administrative support and resources availed might have influenced the implementation and effectiveness of the PBL. Lastly, on constrains, the student background and socio-economic status and prior-experiences might have influenced their engagement and success with PBL.

As this study used the positivism paradigm, diagrammatic presentations such as Charts, tables, graphs were being used. Cross-tabulation for analysing data was employed in this study as it proved to be the most suitable quantitative data analysis method which uses a basic tabular form to draw inferences between different data-sets in the research study. Statistical independent t-test was also utilised in the testing of the null hypothesis. The researcher used triangulation to show that the research study's findings are credible. According to Patton (2016) triangulation refers to the multiple methods or data sources in qualitative research to develop a comprehensive understanding of a phenomena. All respondents reported their written acceptance regarding their participation in the research, through a signed Consent and Briefing Letter.

RESULTS

The Effects of Project-Based Teaching and Learning on Learners

The data revealed that most of the respondents were of the view that Geometrical transformations learning through the use of project-based teaching and learning is very effective and efficient. Evidence from the 84% (65% strongly agree+19% agree) of the respondents harmonized and concurred that in the learning of Geometrical transformations Project-based teaching method encourages independence, helps students gain and develop 21st century competencies such as critical thinking, creativity, collaboration and problem-solving skills. The 84% respondents also strongly consent that PBL allow students to develop deep content knowledge, assists learners to be directly involved in making decisions about the topic focus and the investigations involved. More so, they supplemented that the PBL increases motivation to learn, engagement and participation of learners in Geometrical transformations learning at Ordinary Level. However, a small number of respondents, that is 11%(5%disagree +6%trongly disagree) of the respondents differed from the previously asserted declarations. They disagreed that the project-based teaching method may instill 21st century skills, promoting critical thinking and collaboration in the learning of Geometrical transformations at ordinary level.

Only 5% of the respondents were uncertain, they were unsure and indeterminate on the project-based teaching and learning effectiveness. All in all, the data showed that most respondents, believed that the PBL is very operational.

Project-Based Versus Traditional Teaching Methods

Astounding and overwhelming 90%(69% strongly agree+ 21% agree) of respondents established that the project-based teaching is the most effective way of developing students research skills than traditional method, fosters and enhance learners' autonomy, motivation and engagement than traditional method and settled that it provides an interactive and engaging learning experience that requires learners to apply their knowledge in real-world contexts as compared to traditional teaching method. The 90% credited that PBL provide learners with an increased efficiency in technological aspects than traditional method and that learners are much involved in the learning process such that they feel learning is meant for them, learning becomes more relevant and meaningful. The minor 6%(4% disagree + 2 strongly disagree) retorted that the project-based teaching and learning method is not the most effective way of teaching and learning Geometrical transformations in Mathematics as a subject. Hence, the 6% conflicted that the project-based teaching and learning enables learners to acquire and apply knowledge in real-life aspects, fostering relational understanding on Geometrical transformations concepts. Lastly, a 4% of the respondents reacted undecided and irresolute pertaining the aspect of project-based teaching and learning as compared to the traditional teaching method.

Respondents revealed that PBL provide learners with a sense of ownership and autonomy, allowing them to feel more invested in their learning which in turn increases motivation and engagement. Because learners are much involved in the learning process they feel that learning is meant for them, learning becomes relevant and meaningful.

Challenges in the Implementation of PBL

Quite a number of respondents 84% (69% strongly agree + 15% agree) strongly retorted that the Project-based teaching and learning method is time consuming and leads to incomplete projects, some learners struggle to grasp the concept of project-based teaching methods and that the Project-based learning is more difficult to assess the progress of students as compared to the traditional learning method. They also indicated that the project-based teaching and learning is stressful to both the learner and the teacher as lack of resources limits the effectiveness of the project-based learning approach. However, the 10%(5% strongly disagree + 5% disagree) of the respondents diverge from the former statements supporting that the project-based teaching and learning is not time consuming and does not lead to incomplete projects. The responses also revealed that the 10% argued that learners do not struggle to grasp the concepts taught using the project-based teaching methods. They also supported that the project-based teaching and learning is not difficult and stressful to assess the progress of learners. The remaining 6% indicated that they were uncertain on the challenges being faced by teachers in the implementation of the project-based teaching and learning.

Establishing from the above information, it is crystal clear that the project-based teaching method is demanding and nerve-racking to both the learner and the teacher as shortage of resources limits the effectiveness of the project-based learning approach. More so, the project-based teaching method is time consuming and leads to partial or incomplete tasks in a given project, some learners battle and strain to grasp the concept of project-based teaching methods and that the Project-based learning is more difficult to assess the progress of students.

Observed Student Engagement

Data observed on engagement revealed that 90% of the project-based learners were being involved in the learning process, through participating in class, asking tangible and sensible questions for relational understanding in the geometric concepts. Most learners showed that they were intrinsically motivated to carry the projects in the learning of Geometrical concepts through the project-based teaching and learning method.

Learners showed great interest in the learning process. They felt they had a greater percentage in contributing to the creation of new knowledge. They were willing to go an extra mile in carrying out project tasks. Social engagement was noted through group work interactions they created themselves in helping each other. These observations suggest that the project-based teaching and learning method inculcate a sense of belonging in learners and hence create the zeal and curiosity to explore more on a particular topic or concept for relational understanding.

Observed Learner-Teacher Consultation

An approximated value of 25% of the observed data originated from consultations with the teacher on given Geometrical concepts on transformation. Learners who consulted seemed to grasp the concepts quickly and showed relational understanding than those who did not consult. Grounding on this observation, this means that consultations carry a very significant role as they provided the opportunity for individualised support to students in understanding expectations and demands of the project. Clarifying goals, mapping out a correct plan and learning new strategies, techniques, and necessary tools to attain success while maintaining overall well-being.

Observed Learner Collaboration

The researcher noted that about 25% of the observed data on PBL was derived from learner collaboration. Learners were very active, through oral communication on the given tasks collaboratively and formulating effective team work. Owing to this observation, it is evident that the project-based teaching and learning method encourages team work, leadership skills, communication skills, collaborative learning, positive interdependence and interpersonal skills.

Observed General Performance

22% of the observed data stemmed from general performance of the sample. Respondents performed well in classroom participation, they also showed high intrinsic motivation, they showed a high drive in classwork and assignments and group work given. The observed data focused on students' ability to analyse and evaluate information, think creatively and apply knowledge to solve authentic problems in the project, knowledge and content acquisition, assessing the depth and breadth of student's understanding and grasp of the subject matter addressed in the project, thus observing students' ability to apply and connect learned concepts and skills .This suggest that learners taught using the PBL are able to generate most of the 21st century skills such as critical thinking creativity, communication skills, negotiating and problem-solving skills.

Perceptions of Respondents

Voluminous respondents stretching to an averaged 86%(72% strongly agree + 14% agree) perceived that the Project-based provides opportunity for them to explore complex topics and concepts in-depth, and to apply their learning to real-world problems. Both teacher-respondents and learner respondents Learners (86%) perceived project-based learning positively agreeing that it provides an interactive and engaging learning experience that requires them to apply their knowledge in real-world contexts. They consented that most learners appreciated and felt proud to have the opportunity to take ownership of their learning and to have some autonomy in choosing how to approach the project and that learners felt motivated when they are being engaged in the project as project-based learning encourages critical thinking, problem-solving and decision making as they navigate through the learning process. A trivial 8% (3% strongly disagree +5% disagree) distressed that the project-based teaching method supports opportunities to discover and explore complicated topics and able to relate them to real-life situation. This minor percentage of respondents disagreed that the project-based teaching and learning does not provide an interactive and engaging learning experience to learners. Nevertheless, an insignificant 6% of the respondents returned that they were uncertain on providing responses on presented survey questions.

Rendering to the above data presented it is crystal clear that utmost respondents approved that the project-based teaching and learning in the teaching and learning of geometry encourages critical thinking, problem-solving and decision making as they navigate through the learning process. This suggest that the project-based teaching and learning was preferred by most respondents, both the teacher-respondent as well as the learner-respondent.

EXPERIMENT RESULTS

Assumptions Checked Before the Two-Sample T-Test

The researcher checked for Independence, Normality, Variances, No significant outliers before the experiment on the two classes. The samples were independent and there was no pairing or matching between the samples. The sample size was large enough to assume normality as well as equal variances. The first assessment written before intervention showed that there were no outliers.

Assessment Before Intervention

Table 1 showing assessment results before interventions

Mark (%)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-90	Mean%
Form 3A	3	11	16	9	2	3	2	0	0	27
Form 3∝	5	9	18	8	3	2	1	0	0	28

number of learners in group A=46 number of learners in group B= 46

Results showed no significance difference between the two groups.

Assessment After Intervention

Table 2 showing assessment results after intervention

Mark	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-100	Mean %
Form 3A	3	5	8	10	7	6	3	4	0	48
Form 3∝	0	1	2	2	13	7	9	7	5	67

The three Alpha was taught Geometrical transformations using the PBL method whereas the 3A was taught transformation without PBL method. The mean mark for the 3A was 48% and the mean mark for 3 Alpha was 67%. From 3A 20 out of 46 learners (43%) obtained at least 50% in their assessment test and 26 out of 46 (57%) failed the assessment test. In form 3Alpha, 41 out of 46 learners (89%) obtained at least 50% in the assessment test and only 5 learners out of 46 (11%) failed the assessment test. By merely looking at the displayed figures in the Table showing results after intervention one may easily see that learners in Form 3Alpha performed well than Form 3A. This suggests that the project-based teaching method is more effective in the learning of Geometrical concepts at ordinary level.

HYPOTHESIS TESTING

- $H_{0:}\mu_1=\mu_2$

There is no significant difference in the performance of learners taught geometry using PBL method as compared to those taught without intervention.

- $H_{1:}\ \mu_1>\mu_2$

There is a positive significant difference between the performance of learners taught geometry using the PBL method as compared to those taught without intervention.

Decision and Conclusion: At 5% level of significance we reject H_0 since the calculated t-test value **1.3** is less than the t-test critical value **1.65** and conclude that there is a positive significance difference between the project-based teaching method and the traditional teaching method.

The results of the two-sample t-test indicated a significant difference in the mean scores of learners taught using PBL (Mean =67 and SD=19.5) and Traditional methods (Mean=48 and SD=17.4). The mean difference between the two groups was 19. These findings suggest that PBL may be a more effective method for teaching geometrical transformation rather than traditional methods.

DISCUSSION

The results of the study revealed that the PBL in the teaching and learning of Geometrical transformation at Ordinary level has been found to be positively multi-dimensional. The most imperative acknowledged effects were that; Project-based teaching method encourages independence, helps students gain and develop 21st century competencies such as critical thinking, creativity, collaboration and problem-solving skills. Project-based learning activities were found to allow students develop deep content knowledge, assists learners to be directly involved in making decisions about the topic focus and the investigations involved. Profound information suggested that the Project-based teaching increases motivation to learn, engagement and participation of learners in geometry learning at Ordinary Level.

The findings of this study further indicated that PBL is the most effective way of developing students research skills, fosters and enhance learners' autonomy, motivation and engagement than traditional method. The Project-based teaching and learning was found to provide an interactive and engaging learning experience that requires learners to apply their knowledge in real-world context as compared to the traditional teaching and learning method in the learning of transformation at ordinary level. More so, results showed that the Project-based teaching and learning provide learners with an increased efficiency in technological aspects than traditional method. Learners are much involved in the learning process such that they feel learning is meant for them, learning becomes more relevant and meaningful.

CONCLUSION AND RECOMMENDATIONS

In a nutshell the evaluation of the effectiveness of the PBL in the learning of Geometrical transformation in one of the selected schools in Marondera district revealed that it is one of the most effective teaching method. PBL proved to be encouraging independence, helps students gain and develop 21st century competencies such as critical thinking, creativity, collaboration and problem-solving skills in the process of learning. PBL was found to increase motivation to learn, engagement and participation of learners in transformation learning at Ordinary Level. Results outcome settled that the project-based teaching method in the learning of transformation provides an interactive and engaging learning experience that requires learners to apply their knowledge in real-world contexts as compared to traditional teaching method.

However, the research results from respondents also showed that the Project-based teaching and learning method is time consuming and leads to incomplete projects. Hence, it is recommended that classroom practitioners clearly outline the project's objectives, deliverables and timelines as this will assist both the teacher and the learner create a project schedule with milestones and deadlines. More so, teachers are recommended to use task delegation and work collaboratively to manage time efficiently. The provision of a detailed rubric and assessment criteria might help learners to understand the evaluation process and provide learners with a curated list of relevant resources such as textbooks, articles, or online tutorials. Teachers may also use time-tracking tools such as Trello or Asana to track progress and stay organized. Technology Integration and Digital Tools such as GeoGebra, Geometer's sketchpad to facilitate quick exploration and visualization. By implementing these strategies teachers can help mitigate the time-consuming nature of PBL when teaching geometrical transformations, while still providing learners with a rich and engaging learning experiences. Another limitation on resources teachers are recommended to utilise free or low cost Digital Resources such as Maths Open Reference and GeoGebra .in addition to, both teachers and learners might opt

for repurpose and reuse existing material for instance, use outdated textbooks as a resource for project ideas diagrams or problems. The teachers might utilize or incorporate everyday objects such as scissors papers, mirrors to demonstrate geometrical transformations. Learners are recommended to create their own Geometrical tools like protractors and compasses using locally available materials. Schools are also encouraged to reach out to local businesses and organisations if facing resource challenges in the implementation of the PBL in the teaching of Geometry. The study recommended that the curriculum planners and designers should emphasise on the use of project-based teaching method when teaching transformations at ordinary level for relational understanding as PBL method encourages students to learn skills and apply their knowledge by taking part in a project.

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